

### **REMARKS/ARGUMENTS**

The claims pending in this application are claims 19-33 as presented in the Amendment of August 20, 2008. The listing of claims in the Office Action Summary is inaccurate – claims 19-33 are pending and presumably, from the examiner's comments on page 2, first paragraph, claims 28-33 are considered withdrawn from consideration as directed to non-elected subject matter. Applicants traverse this continued requirement for restriction for the reasons pointed out below. However, the record should reflect the correct claims being considered in this application.

Submitted with this response is an evidentiary declaration of Tomas Landh, one of the joint inventors of the subject application. The significance of this declaration is explained in more detail below.

Applicant notes that the Examiner has made the restriction requirement final, and the application has been restricted to Group I, i.e. claims 19-27 (directed to the microemulsion itself). The Examiner considers the reversed-phase microemulsion of the current claims to be simply another form of known oil-in-water emulsions and therefore obvious in view of the combination of US 6,506,803 (Baker *et al*) and US 5,618,840 (Wright *et al*). The applicant still considers claims 28-33 share a special technical feature and are therefore unified. Nonetheless, the examiner is requested to consider rejoining other claims upon the allowance of claims 19-27.

In item 3 of the Office Action the Examiner has maintained the obviousness rejections in spite of the Wollmer declaration which was filed as part of the last response. The prior declaration was not considered to be sufficient to overcome the Examiner's rejection, so submitted herewith is a further declaration from the other joint-inventor of the current application in an effort to address the Examiner's additional points. Applicant also offers the following additional comments.

The Examiner considers that the combination of Baker *et al* and Wright *et al* teaches the preparation of emulsions comprising 5-50 % aqueous phase, 30-90 % oil phase (which may include sesame oil) and 3-15 % surfactant and glycerol esters including glycerol monooleate which are useful as stable antibacterial emulsions for inactivating bacteria and decreasing the infectivity, morbidity and rate of mortality associated with a variety of pathogenic organisms. It is difficult to address this assertion directly because there is no indication of where these

combinations and ranges of component proportions are found. One important issue to address immediately, however, is the statement three lines from the top of page 4;

"... would result in oil in water phase i.e. reversed phase microemulsion".

This phrase is factually incorrect in two respects which may lead to the continued misunderstanding of the present invention. In fact, "oil in water phase" is a *normal* phase; it is "water in oil" which is *reversed* phase. This is one of the key distinctions between the present invention and the prior art (see below and previous submissions) and thus it is highly important that the Examiner appreciates the way in which this nomenclature is used. In addition, the Examiner is confusing "emulsion" with "microemulsion". Although these terms appear similar and both relate to mixtures of immiscible liquids, emulsions and microemulsions are structurally and functionally quite different. This is discussed in detail below and in the enclosed declaration. Thus, as general background to the invention, it is essential to appreciate that the present claims relate to *reversed phase microemulsions* and not to either *emulsions* or anything of *normal phase* (oil-in-water).

In items 4-5 of the Office Action the Examiner objects that the amendment to specify "reversed phase" microemulsions does not have specific basis in the application as filed. It will be noted that the Wollmer declaration submitted with the last response covers this point very clearly: the reversed phase nature of the claimed microemulsions is an *inherent property* of the compositions of the invention and would be recognized as such by the skilled man. Thus this is implicitly disclosed throughout the application as filed and this amendment does not expand the scope of the original disclosure. The amended claims make this inherent property explicit and in fact was suggested by Examiner Blessing during the interview of May 29, 2008 as specifically discussed in the Interview Statement of June 17, 2008.

See also the article by Leser *et al* in support of this position, which was filed with the Wollmer declaration and on which the Examiner has not commented.

The lipids in the formulations, glycerol monooleate and sesame oil, cannot in themselves form the curvature required for an oil-in-water microemulsion. In other words, the curvature of the lipids used is such that they will inevitably form reversed phase microemulsions unless used with other components having positive curvature in amounts that would dominate the phase behavior (such as in Baker *et al* and Wright *et al*). No such dominant components are taught

towards in the present case. It should thus be clear to one skilled in the art that the invention applies to reversed-phase microemulsions. The article by Leser *et al* contains some discussion on similar systems, for example, section 3.1.

In items 6-8 of the Office Action the Examiner maintains her objection that the claims are obvious in view of the combination of Baker *et al* and Wright *et al*.

Column 2 (lines 17-22) of Wright *et al* states that oils useful in forming the oily **discontinuous** phase (i.e. normal phase structures) include a broad spectrum of water immiscible materials. Among the dozen listed (including such generic terms as "fish oil") is sesame oil. Sesame oil is ascribed no particular advantages among the many water immiscible materials listed by Wright *et al*, yet the Examiner has chosen to take this disclosure as motivation for the skilled man to use sesame oil in a microemulsion comprising 35 % of oil phase and 10 % of aqueous phase (as is considered to be taught by Baker *et al*). The Examiner argues that this would inevitably form a reversed phase microemulsion and therefore the prior art teaches a reversed phase microemulsion which maintains its negative spontaneous curvature and can be used in biological fluids for inactivating bacteria and for decreasing the infectivity of pathogenic organisms in foodstuffs. This is not correct.

The skilled man *could* combine sesame oil with the disclosures of Baker *et al*, but there is no reason why he *would* do so. No motivation is provided in either document for this combination. Furthermore, not only would this combination not result in reversed phase structures, but it would not result in microemulsions of any sort. There is no reasonable expectation of success (*see In re Rinehart*, 189 USPQ 143, 148, CCPA 1970) hence a case of "obviousness" has not been established.

Submitted herewith is a declaration from Tomas Landh made October 26, 2009, who is joint inventor on the present application and has worked for many years in the field of lipid structures, emulsions and microemulsions. Dr Landh notes at section 4 that traditional emulsions are the opaque dispersion of one phase in another which is familiar to most scientists. These are cloudy since they contain stabilized droplets of one phase suspended within another. They are also not thermodynamically stable and although they may be long-lived, will eventually separate and require a very significant input of energy to create them. These are the emulsions described by Baker *et al* and Wright *et al*.

In contrast to traditional emulsions, the present application relates to "microemulsions". These are understood by the skilled worker to be thermodynamically stable transparent structures which are quite different in both appearance and property to traditional emulsions. The present application relates to microemulsions, and the prior art to emulsions. The teaching from one thus does not render the other obvious. Since the Examiner seems reluctant to accept the statement of experts in the field in these matters, additionally attached are corresponding Wikipedia extracts.

The second issue, and the one which was addressed with the last declaration was that of reversed or normal phase. The Examiner is correct in that certain components used in Baker *et al* and Wright *et al* may have negative spontaneous curvature, but in a mixture of components the overall phase behavior is the result of the properties of all components and their interactions. As Dr Landh points out at section 8 of the enclosed declaration, it is entirely possible for components with negative spontaneous curvature to be included in normal phased structures if mixed with other components which are either in greater quantity or which have a more pronounced positive curvature. The point made in the declaration submitted previously is that *all* of the key components of the present claims have a negative curvature and thus the overall system must be the same. This is most abundantly not the case with Baker *et al* and Wright *et al* since they explicitly disclose and teach towards "oil-in-water" emulsions, which are always *normal phase*. Thus in the mixtures of Baker *et al* and Wright *et al* the components of positive curvature dominate. In the present invention the reverse applies.

Finally, it is not clear where the Examiner has obtained the numbers which quotes (35% of oil phase and 10% of aqueous phase), nor what the examiner envisages the remaining 55% of the composition to be. On the contrary, the use of sesame oil in the emulsions of Baker *et al* would seem to produce an emulsion comprising 30-90 vol.% sesame oil, 5-50 vol.% aqueous phase, 3-15 vol.% surfactant and 3-15 vol.% organic solvent (Column 10, lines 50-68 Baker *et al*), which would not encompass a microemulsion and would not be a reversed phase structure such as that claimed in the current application.

The claims of the current application are directed to a reversed phase microemulsion comprising 5-35 wt.% of a non-polar animal or vegetable oil; 10-55 wt.% of at least one polar solvent; at least one surfactant; and 20-50 wt.% of a monoacyl glycerol.

Baker *et al* is considered by the Examiner to disclose an emulsion composition comprising 30-90 wt.% oil phase; 5-50 wt.% aqueous phase (reading onto polar solvent); and 3-15 wt.% of surfactant such as polysorbate detergents, wherein the aqueous phase comprises water.

The applicant submits that following Baker would not lead to the present invention, for the following reasons.

The Examiner refers to Column 14 of Baker *et al* as disclosing an emulsion composition comprising GMO in the initial oil phase and suitable carriers such as fatty acids and polyethylene glycols, wherein the water to oil phase ratio "ranges from 4:1". The Examiner takes this as reading onto reversed phase microemulsions. However, a water:oil ratio of 4:1 has a greater proportion of water and would typically lead to a *normal phase*, oil-in-water emulsion. Furthermore, this is clearly and explicitly what Baker is teaching towards. Moreover, although Table 1 in Column 14 of Baker *et al*. discloses oil phase compositions comprising GMO, the percentages of GMO in the oil phases NN, P10 and SS are around 12 %, which upon dilution with water in the listed ratios falls to approximately 3 %, significantly less than the range of GMO required in the compositions of the current invention.

As indicated in sections 11 and 12 of the enclosed declaration, Dr Landh has extensive practical experience generating compositions related to those claimed in the present invention. It is his belief based upon this practical knowledge that around 20% or more of GMO would be required in the compositions in order to generate reversed phase microemulsions. This is a very long way from the value of 3% in the final compositions of Baker *et al*. and significantly greater than even the intermediate compositions having up to around 12%. Thus it is neither taught towards nor inherent that the compositions of Baker *et al*. would be reversed phase microemulsions.

Furthermore, Column 13 of Baker *et al*. (lines 22-49) discloses details of the synthesis of the oil-in-water emulsions used therein. These are discussed in terms of the classic emulsion forming techniques known in the art, wherein relatively high shear forces are used to obtain an oil-in-water emulsion containing oil droplets of approximately 0.5-5 micrometres. These are described as droplets of an oily discontinuous phase dispersed in an aqueous continuous phase,

such as water. From this it is clear that Baker *et al.* relates to standard emulsions, rather than reversed phase microemulsions. The enclosed Wikipedia extracts further support this view.

In the current application, average droplet sizes are in the range 5-200 nm and less than 0.1 % exceed 500 nm, preferably less than 0.1 % exceed 250 nm (page 3, paragraph [0034]). In contrast, in Baker *et al* the oil phase is preferably distributed throughout the aqueous phase as droplets having a mean particle size in the range from about 1-2 microns (i.e. 1000-2000 nm), preferably 0.2-0.8 microns, more preferably 0.8 microns, i.e. in the range 200-800 nm, preferably around 800 nm. The smallest particle exemplified by Baker *et al.* is 625 nm (example 1, table 2). These are clearly particles of a traditional oil-in-water emulsion, as would be expected from the explicit disclosure of Baker *et al.*

The Examiner also refers to the disclosure of Column 23 (lines 28-32) of Baker *et al* as teaching that the emulsion compositions can be administered in any effective pharmaceutically acceptable forms to warm blood animals, such as oral, nasal, buccal, rectal, vaginal, topical or nasal spray or in any other form effective to administer the active composition. This has been coupled with the teaching of Column 5 (lines 25-41) of Baker *et al* that compositions are useful for decreasing the infectivity of pathogenic organisms in foodstuffs, in particular, decreased pathogenic organism infectivity, morbidity and mortality being achieved by contacting the pathogenic organism with an emulsion comprising an oil, an organic solvent, and a surfactant dispersed in an aqueous phase.

Again, these disclosures relate to oil dispersed in an aqueous phase, i.e. oil in water emulsions, not water-in-oil microemulsions. In addition, the functional part of this composition is the organic solvent, with the emulsion acting solely as a carrier, as described in the section of Baker *et al.* from Column 15, line 50 to Column 16, line 50, and in particular, Column 16, lines 34-40, i.e. "...the organic phosphate-based solvents employed in the emulsions serve to remove or disrupt the lipids in the membranes of the pathogens...". Why, therefore, would the skilled man expect a microemulsion which does not comprise these disruptive solvents to be effective in remotely the same way? There seems no correlation between this disclosure and the claimed compositions.

The Examiner has also brought in the disclosure in Column 5 that the emulsions have the additional advantage of being readily diluted with water and retaining their stability and structure

when diluted. However, as a feature of oil in water emulsions this is not surprising, as the oil is already dispersed in an excess of water/aqueous solution and this situation would not be greatly affected by dilution with further water/aqueous solution. Indeed, in a traditional emulsion such as that disclosed by Baker *et al.* only dilution with the continuous phase is typically possible, thus this disclosure of this fact only emphasises the normal-phase nature of the compositions of Baker and further distinguishes from the reversed phase compositions of the present case.

The Examiner considers that the emulsions of Baker *et al.* differ from the emulsions of the current invention only in their failure to disclose the specific amount of monoacyl glycerol required. However, the Examiner considers that Wright *et al.* disclose an antibacterial oil-in-water emulsion comprising droplets of oily phase (such as sesame oil) and mono glycerol ester (GMO or GMS) in the range of 12-21 wt. % (Column 6, Example 1). The Examiner also cites the teaching of the abstract of Wright *et al.* that the emulsions can be administered to individuals, for example, orally, to treat or prevent *Helicobacter Pylori* infection.

However, as with the disclosures in Table 1 of Baker *et al.*, when the GMO content of the overall oil/water composition is calculated, the GMO content turns out to be less than 5% GMO, i.e. significantly less than is required in the compositions of the current invention. There is no motivation provided to increase this level of GMO and no disclosure or teaching of possibly advantageous properties to be achieved by so doing. Thus even if these disclosures were combined as proposed by the Examiner, the result would not fall within the present claims, either compositionally or behaviorally.

The Examiner considers that it would be obvious to the skilled man to incorporate GMO into the emulsion taught by Baker, and to use Sesame oil therein. The Examiner further considers that the skilled man would be motivated to combine these teachings because Baker teaches that the emulsions prepared are useful for decreasing the infectivity of pathogenic organisms in foodstuffs and therefore the skilled man would have had a reasonable expectation of success.

However, the Examiner has not defined in what way the skilled man would expect to be successful. What is the objective? There is no definition of a technical aim or problem to be solved by the skilled man which would lead him to combine these references. Furthermore, in view of the above, it is clear that even if the skilled man were motivated to combine the selected

teachings of Baker *et al* and Wright *et al* they would not obtain the water-in-oil microemulsions of the current invention.


The compositions of the current invention differ in particle size, phase behavior, GMO content and most importantly, mechanism from any of the prior art. There cannot, therefore be any reasonable expectation of success in combining un-expected proportions of ingredients to generate wholly differing structures, omitting the active agent to provide an entirely undisclosed mechanism of action. Baker *et al* and Wright *et al* purport to rely on organic phosphates to break down micro-organisms, whereas the compositions of the current invention rely on capture and envelopment/entrapment of particles.

For the above reasons it is respectfully submitted that all pending claims define patentable subject matter. Reconsideration and allowance are solicited. Should the examiner require further information, please contact the undersigned.

Respectfully submitted,

NIXON & VANDERHYE P.C.

By: \_\_\_\_\_

  
Arthur R. Crawford  
Reg. No. 25,327

ARC:eaw  
901 North Glebe Road, 11th Floor  
Arlington, VA 22203-1808  
Telephone: (703) 816-4000  
Facsimile: (703) 816-4100



# Emulsion

From Wikipedia, the free encyclopedia

An **emulsion** (IPA: /ˈɛmʊlən/ <sup>[1]</sup>) is a mixture of two or more immiscible (unblendable) liquids. Emulsions are part of a more general class of two-phase systems of matter called colloids. Although the terms colloid and emulsion are sometimes used interchangeably, emulsion tends to imply that both the dispersed and the continuous phase are liquid. In an emulsion, one liquid (the dispersed phase) is dispersed in the other (the continuous phase).

Examples of emulsions include vinaigrettes, the photo-sensitive side of photographic film, milk and cutting fluid for metal working.

## Contents

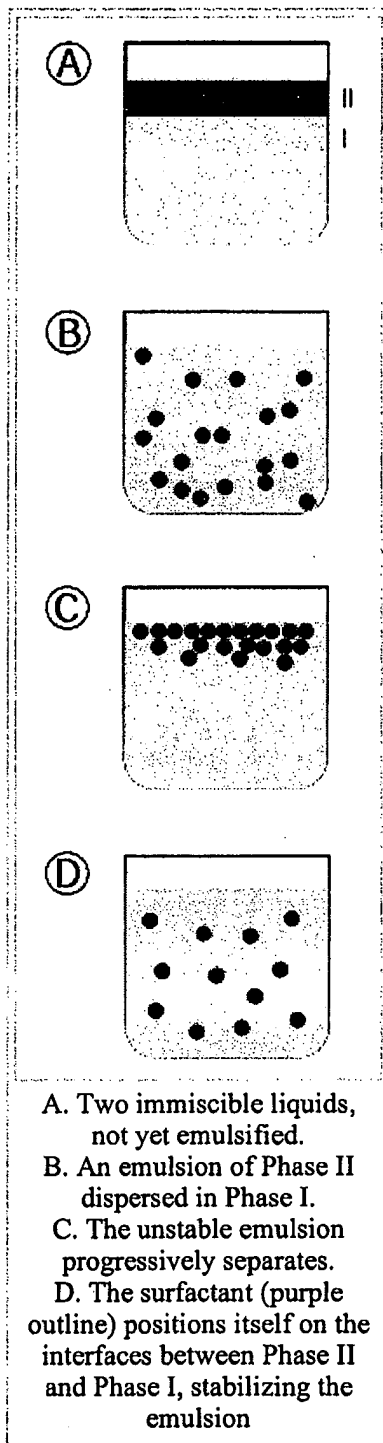
- 1 Appearance and Properties
- 2 Emulsifier
- 3 In medicine
- 4 In fire fighting
- 5 See also
- 6 References

## Appearance and Properties

Emulsions tend to have a cloudy appearance, because the many phase interfaces (the boundary between the phases is called the interface) scatter light that passes through the emulsion. Emulsions are unstable and thus do not form spontaneously. Energy input through shaking, stirring, homogenizing, or spray processes are needed to form an emulsion. Over time, emulsions tend to revert to the stable state of the phases comprising the emulsion. Surface active substances (surfactants) can increase the kinetic stability of emulsions greatly so that, once formed, the emulsion does not change significantly over years of storage. Vinaigrette is an example of an unstable emulsion that will quickly separate unless shaken continuously. This phenomenon is called coalescence, and happens when small droplets recombine to form bigger ones. Emulsions can also suffer from creaming, the migration of one of the substances to the top of the emulsion under the influence of buoyancy or centripetal force when a centrifuge is used.

There are three types of emulsion instability: flocculation, where the particles form clumps; creaming, where the particles concentrate towards the surface (or bottom, depending on the relative density of the two phases) of the mixture while staying separated; and breaking and coalescence where the particles coalesce and form a layer of liquid.

Whether an emulsion turns into a water-in-oil emulsion or an oil-in-water emulsion depends on the volume fraction of both phases and on the type of emulsifier. Generally, the Bancroft rule applies: emulsifiers and emulsifying particles tend to promote dispersion of the phase in which they do not dissolve very well; for example, proteins dissolve better in water than in oil and so tend to form oil-



in-water emulsions (that is they promote the dispersion of oil droplets throughout a continuous phase of water).

The basic color of emulsions is white. If the emulsion is dilute, the Tyndall effect will scatter the light and distort the color to blue; if it is concentrated, the color will be distorted towards yellow. This phenomenon is easily observable on comparing skimmed milk (with no or little fat) to cream (high concentration of milk fat). Microemulsions and nanoemulsions tend to appear clear due to the small size of the disperse phase.

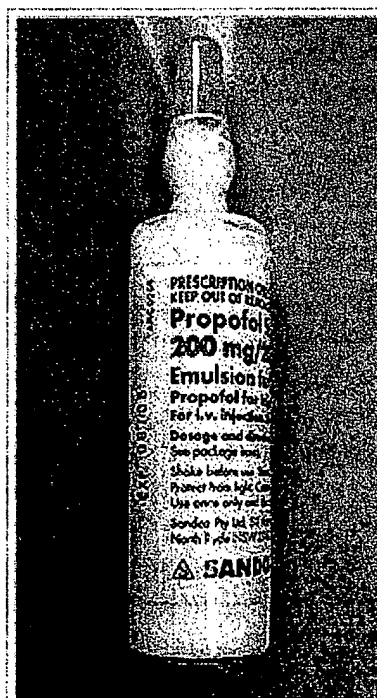
## Emulsifier

An emulsifier (also known as an emulgent) is a substance which stabilizes an emulsion, frequently a surfactant. Examples of food emulsifiers are egg yolk (where the main emulsifying chemical is lecithin), honey, and mustard, where a variety of chemicals in the mucilage surrounding the seed hull act as emulsifiers; proteins and low-molecular weight emulsifiers are common as well. Soy lecithin is another emulsifier and thickener. In some cases, particles can stabilize emulsions as well through a mechanism called Pickering stabilization. Both mayonnaise and Hollandaise sauce are oil-in-water emulsions that are stabilized with egg yolk lecithin. Detergents are another class of surfactant, and will physically interact with both oil and water, thus stabilizing the interface between oil or water droplets in suspension. This principle is exploited in soap to remove grease for the purpose of cleaning. A wide variety of emulsifiers are used in pharmacy to prepare emulsions such as creams and lotions. Common examples include emulsifying wax, cetearyl alcohol, polysorbate 20, and cetareth 20.<sup>[2]</sup> Sometimes the inner phase itself can act as an emulsifier, and the result is **nanoemulsion** - the inner state disperses into nano-size droplets within the outer phase. A well-known example of this phenomenon, the ouzo effect, happens when water is poured in a strong alcoholic anise-based beverage, such as ouzo, pastis, arak or raki. The anisolic compounds, which are soluble in ethanol, now form nano-sized droplets and emulgate within the water. The colour of such diluted drink is opaque and milky.

## In medicine

In pharmaceuticals, hairstyling, personal hygiene and cosmetics, emulsions are frequently used. These are usually oil and water emulsions, but which is dispersed and which is continuous depends on the pharmaceutical formulation. These emulsions may be called creams, ointments, liniments (balms), pastes, films or liquids, depending mostly on their oil and water proportions and their route of administration.<sup>[3][4]</sup> The first 4 are topical dosage forms, and may be used on the surface of the skin, transdermally, ophthalmically, rectally or vaginally. A very liquidy emulsion may also be used orally, or it may be injected using various routes (typically intravenously or intramuscularly).<sup>[3]</sup> Popular medicated emulsions include calamine lotion, cod liver oil, Polysporin, cortisol cream, Canesten and Fleet.

Microemulsions are used to deliver vaccines and kill microbes.<sup>[5]</sup> Typically, the emulsions used in these techniques are nanoemulsions of soybean oil, with particles that are 400-600 nm in diameter.<sup>[6]</sup> The process is not chemical, as with other types of antimicrobial treatments, but physical. The smaller the droplet, the greater the surface tension and thus the greater the force to merge with other lipids. The oil is emulsified using a high shear mixer with detergents to stabilize the emulsion, so when they encounter



20 ml ampule of 1% propofol emulsion suitable for intravenous injection. The

the lipids in the membrane or envelope of bacteria or viruses, they force the lipids to merge with themselves. On a mass scale, this effectively disintegrates the membrane and kills the pathogen. This soybean oil emulsion does not harm normal human cells nor the cells of most other higher organisms. The exceptions are sperm cells and blood cells, which are vulnerable to nanoemulsions due to their membrane structures. For this reason, these nanoemulsions are not currently used intravenously. The most effective application of this type of nanoemulsion is for the disinfection of surfaces. Some types of nanoemulsions have been shown to effectively destroy HIV-1 and various tuberculosis pathogens, for example, on non-porous surfaces.

manufacturers emulsify the lipid soluble propofol in a mixture of water, soy oil and egg lecithin.

## In fire fighting

Emulsifying agents are effective at extinguishing fires on small thin layer spills of flammable liquids (Class B fires). Extinguishment is achieved by encapsulating the fuel in a fuel-water emulsion thereby trapping the flammable vapors in the water phase. This emulsion is achieved by applying an aqueous surfactant solution to the fuel through a high pressure nozzle.

Emulsifiers are not effective at extinguishing large Class B fuel in depth fires. This is because the amount of agent needed for extinguishment is a function of the volume of the fuel whereas agents such as aqueous film forming foam (AFFF) need only cover the surface of the fuel to achieve vapor mitigation.

## See also

- Emulsion dispersion
- Microemulsion
- Miniemulsion

## References

1. ^ Emulsion - Definitions from Dictionary.com (<http://dictionary.reference.com/browse/Emulsion>)
2. ^ Anne-Marie Faiola (2008-05-21). "Using Emulsifying Wax (<http://www.teachsoap.com/emulsifywax.html>)". *TeachSoap.com*. TeachSoap.com. <http://www.teachsoap.com/emulsifywax.html>. Retrieved 2008-07-22.
3. ^ <sup>a</sup> <sup>b</sup> Aulton, Michael E., ed (2007). *Aulton's Pharmaceutics: The Design and Manufacture of Medicines* (3rd ed.). Churchill Livingstone. pp. 92-97, 384, 390-405, 566-69, 573-74, 589-96, 609-10, 611,. ISBN 9780443101083.
4. ^ Troy, David A.; Remington, Joseph P.; Beringer, Paul (2006). *Remington: The Science and Practice of Pharmacy* (21st ed.). Philadelphia, Pennsylvania, USA: Lippincott Williams & Wilkins. pp. 325-336, 886-87. ISBN 0-7817-4673-6.
5. ^ "Adjuvant Vaccine Development (<http://www.nano.med.umich.edu/Platforms/Adjuvant-Vaccine-Development.html>)". <http://www.nano.med.umich.edu/Platforms/Adjuvant-Vaccine-Development.html>. Retrieved 2008-07-23.
6. ^ "Nanoemulsion vaccines show increasing promise ([http://www.eurekalert.org/pub\\_releases/2008-02/uomh-nvs022608.php](http://www.eurekalert.org/pub_releases/2008-02/uomh-nvs022608.php))". *Eurekalert! Public News List*. University of Michigan Health System. 2008-02-26. [http://www.eurekalert.org/pub\\_releases/2008-02/uomh-nvs022608.php](http://www.eurekalert.org/pub_releases/2008-02/uomh-nvs022608.php). Retrieved 2008-07-22.

Retrieved from "<http://en.wikipedia.org/wiki/Emulsion>"

Categories: Colloidal chemistry | Chemical mixtures | Condensed matter physics | Soft matter | Dosage forms

- This page was last modified on 19 October 2009 at 20:54.
- Text is available under the Creative Commons Attribution-ShareAlike License; additional terms may apply. See Terms of Use for details.

Wikipedia® is a registered trademark of the Wikimedia Foundation, Inc., a non-profit organization.

# Microemulsion

From Wikipedia, the free encyclopedia

**Microemulsions** are clear, stable, isotropic liquid mixtures of oil, water and surfactant, frequently in combination with a cosurfactant. The aqueous phase may contain salt(s) and/or other ingredients, and the "oil" may actually be a complex mixture of different hydrocarbons and olefins. In contrast to ordinary emulsions, microemulsions form upon simple mixing of the components and do not require the high shear conditions generally used in the formation of ordinary emulsions. The two basic types of microemulsions are direct (oil dispersed in water, o/w) and reversed (water dispersed in oil, w/o).

In ternary systems such as microemulsions, where two immiscible phases (water and 'oil') are present with a surfactant, the surfactant molecules may form a monolayer at the interface between the oil and water, with the hydrophobic tails of the surfactant molecules dissolved in the oil phase and the hydrophilic head groups in the aqueous phase. As in the binary systems (water/surfactant or oil/surfactant), self-assembled structures of different types can be formed, ranging, for example, from (inverted) spherical and cylindrical micelles to lamellar phases and bicontinuous microemulsions, which may coexist with predominantly oil or aqueous phases.

## Contents

- 1 Uses
- 2 Theory
- 3 History and terminology
- 4 Phase Diagrams
- 5 See also
- 6 References

## Uses

Microemulsions have many commercially important uses:

- Water-in-oil microemulsions for some dry cleaning processes
- Floor polishers and cleaners
- Personal care products
- Pesticide formulations
- Cutting oils. Much of the work done on these systems have been motivated by their possible use to mobilize petroleum trapped in porous sandstone for enhanced oil recovery

A fundamental reason for the uses of these systems is that a microemulsion phase sometimes has an ultralow interfacial tension with a separate oil or aqueous phase, which may release or mobilize them from solid phases even in conditions of slow flow or low pressure gradients.

Microemulsions also have industrial applications, one of them being the synthesis of polymers. Microemulsion polymerization is a complex heterogeneous process where transport of monomers, free radicals and other species (such as chain transfer agent, co-surfactant and inhibitors) between the aqueous and organic phases, takes place.<sup>[1]</sup> Compared with other heterogeneous polymerization processes (suspension or emulsion) microemulsion polymerization is a more complicated system. Polymerization rate is controlled by monomer partitioning between the phases, particle nucleation, and adsorption and desorption of radicals. Particle stability is affected by the amount and type of surfactant and pH of dispersing medium.<sup>[2]</sup>

The kinetics of microemulsion polymerization has much in common with emulsion polymerization kinetics, the most characteristic feature of which is the compartmentalization, where the radicals growing inside the particles are separated from each other, thus suppressing termination to a high extent and, as a consequence, providing high rates of polymerization.

## Theory

Various theories concerning microemulsion formation, stability and phase behavior have been proposed over the years. For example, one explanation for their thermodynamic stability is that the oil/water dispersion is stabilized by the surfactant present and their formation involves the elastic properties of the surfactant film at the oil/water interface, which involves as parameters, the curvature and the rigidity of the film. These parameters may have an assumed or measured pressure and/or temperature dependence (and/or the salinity of the aqueous phase), which may be used to infer the region of stability of the microemulsion, or to delineate the region where three coexisting phases occur, for example. Calculations of the interfacial tension of the microemulsion with a coexisting oil or aqueous phase are also often of special focus and may sometimes be used to guide their formulation.

## History and terminology

The term microemulsion was first used by Jack H. Shulman, a professor of chemistry at Columbia University, in 1959. Alternative names for these systems are often used, such as **transparent emulsion**, **swollen micelle**, **micellar solution**, and **solubilized oil**. More confusingly still, the term microemulsion can refer to the single isotropic phase that is a mixture of oil, water and surfactant, or to one that is in equilibrium with coexisting predominantly oil and/or aqueous phases, or even to other non-isotropic phases.

## Phase Diagrams

The microemulsion region is usually characterized by constructing ternary-phase diagrams. Three components are the basic requirement to form a microemulsion: an oil phase, an aqueous phase and a surfactant. If a cosurfactant is used, it may sometimes be represented at a fixed ratio to surfactant as a single component, and treated as a single "pseudo-component". The relative amounts of these three components can be represented in a ternary phase diagram. Gibbs phase diagrams can be used to show the influence of changes in the volume fractions of the different phases on the phase behavior of the system.

The three components composing the system are each found at an apex of the triangle, where their corresponding volume fraction is 100%. Moving away from that corner reduces the volume fraction of that specific component and increases the volume fraction of one or both of the two other components. Each point within the triangle represents a possible composition of a mixture of the three components or pseudo-components, which may consist (ideally, according to the Gibbs' phase rule) of one, two or three phases. These points combine to form regions with boundaries between them, which represent the "phase behavior" of the system at constant temperature and pressure.

The Gibbs phase diagram, however, is an empirical visual observation of the state of the system and may, or may not express the true number of phases within a given composition. Apparently clear single phase formulations can still consist of multiple iso-tropic phases (e.g. the apparently clear heptane/AOT/water microemulsions consist multiple phases). Since these systems can be in equilibrium with other phases, many systems, especially those with high volume fractions of both the two immiscible phases, can be easily destabilised by anything that changes this equilibrium e.g. high or low temperature or addition of surface tension modifying agents.

However, examples of relatively stable microemulsions can be found. It is believed that the mechanism for removing acid build up in car engine oils involves low water phase volume, water-in-oil (w/o) microemulsions. Theoretically, transport of the aqueous acid droplets through the engine oil to microdispersed calcium carbonate particles in the oil should be most efficient when the droplets are small enough to transport a single hydrogen ion (the smaller the droplets, the greater the number of droplets, the faster the neutralisation). Such microemulsions are probably very stable across a reasonably wide range of elevated temperatures.

## See also

- Ouzo effect

## References

1. ^ "A Microemulsion Process for Producing Acrylamide-Alkyl Acrylamide Copolymers", S. R. Turner, D. B. Siano and J. Bock, U. S. Patent No. 4,521,580, June 1985.
  2. ^ Ovando V.M. Polymer Bulletin 2005, 54, 129-140
- [1] Ovando V.M. Polymer Bulletin 2005, 54, 129-140.
  - Prince, Leon M., *Microemulsions in Theory and Practice* Academic Press (1977) ISBN 0-12-565750-1.
  - Rosano, Henri L and Clausse, Marc, eds., *Microemulsion Systems (Surfactant Science Series)* Marcel Dekker, Inc. (1987) ISBN 0-8247-7439-6

Retrieved from "<http://en.wikipedia.org/wiki/Microemulsion>"

Categories: Colloidal chemistry | Soft matter

---

- This page was last modified on 7 October 2009 at 15:02.
- Text is available under the Creative Commons Attribution-ShareAlike License; additional terms may apply. See Terms of Use for details.  
Wikipedia® is a registered trademark of the Wikimedia Foundation, Inc., a non-profit organization.